Claims

1. Biodegradable multi-block copolymer, comprising at least two hydrolysable segments derived from pre-polymers A and B, which segments are linked by a multi-functional chain-extender and are chosen from the pre-polymers A and B, and triblock copolymers ABA and BAB, wherein the multi-block copolymer is amorphous at physiological (body) conditions.

2. Copolymer according to claim 1, wherein the copolymer has a glass transition temperature below body temperature at physiological (body) conditions..

3. Copolymer according to claim 1 or 2, wherein pre-polymer A and/or pre-polymer B contain ester and/or carbonate and/or anhydride linkages, optionally in combination with polyethers.

4. Copolymer according to any of the preceding claims, wherein pre-polymer (A) comprises polyether groups.

5. Copolymer according to any of the preceding claims, wherein a polyether is present as an additional pre-polymer.

6. Copolymer according to any of the preceding claims, wherein pre-polymer (A) comprises a reaction product of an ester forming monomer selected from the group of diols, dicarboxylic acids and hydroxycarboxylic acids.

7. Copolymer according to any of claims 1-5, wherein pre-polymer (A) comprises reaction products of at least one cyclic monomer with at least one non-cyclic initiator selected from the group of diols, dicarboxylic acids and hydroxycarboxylic acids.

8. Copolymer according to claim 7, wherein said cyclic monomer is selected from the group of glycolide, lactide (L, D or DL), ε-caprolactone, δ-valerolactone, trimethylene carbonate, tetramethylenecarbonate, 1,4-dioxane-2-one (*para*-dioxanone), 1,5-dioxepane-2-one and/or cyclic anhydrides such as oxepane-2,7-dione.

9. Copolymer according to claim 8 wherein pre-polymer A contains at least two different cyclic monomers, preferably one of them being ε-caprolactone.

10. Copolymer according to claim 9 wherein pre-polymer A consists of glycolide and ε-caprolactone in a 1:1 weight ratio.

11. Copolymer according to claim 8 wherein pre-polymer A consists of glycolide and lactide in a 1:1 weight ratio.

12. Copolymer according to any of previous claims , wherein said non-cyclic monomer is selected from the group of succinic acid, glutaric acid, adipic acid, sebacic acid, lactic acid, glycolic acid, hydroxybutyric acid, ethylene glycol, diethyleneglycol, 1,4-butanediol and 1,6-hexanediol.

13. Copolymer according to any of the claims 3-12, wherein said polyether groups are selected from the group of PEG (polyethylene glycol), PEG-PPG (polypropylene glycol), PTMG (polytetramethylene ether glycol) and combinations thereof.

14. Copolymer according to claim 13, wherein the polyether group is PEG.

15. Copolymer according to claim 14, wherein PEG is an initiator for ring-opening polymerization with a molecular weight between 150-4000, preferably between 150-2000, more preferably between 300-1000.

16. Copolymer according to any of previous claims, wherein pre-polymer (A) has a number average molecular weight (Mn) between 300 and 30000, preferably higher than 500, more preferably between 1000 and 8000.

17. Copolymer according to any of the previous claims, wherein pre-polymer (B) comprises ε-caprolactone, δ-valerolactone, trimethylene carbonate, para-dioxanone, DL-lactide and/or glycolide.

18. Copolymer according to claim 17, wherein pre-polymer (B) contains d,l-lactide, and is preferably poly(d,l-lactide) or poly(lactide-glycolide (50/50)).

19. Copolymer according to claims 17 or 18, wherein pre-polymer (B) has a number average molecular weight (Mn) higher than 300, preferably higher than 1000, more preferably between 2000 and 8000.

20. Copolymer according to any of the claims 16-19, wherein pre-polymer (B) is present in an amount of 10-90 wt.%, preferably 25-75 wt.%, based on the total weight of the copolymer.

21. Copolymer according to any of the previous claims, having an intrinsic viscosity of at least 0.1 dl/g, preferably less than 6 dl/g, more preferably between 0.2-4 dl/g, more preferably between 0.4-2 dl/g.

22. Copolymer according to any of the previous claims, wherein the chain extender is derived from a difunctional aliphatic compound.

23. Copolymer according to claim 22, wherein the chain-extender is a diisocyanate, preferably 1,4-butanediisocyanate.

24. Copolymer according to any of the preceding claims, wherein the pre-polymer segments are randomly distributed in the copolymer.

25. Process for preparing a copolymer according to any of the previous claims, comprising a chain-extension reaction of pre-polymer (A) and pre-polymer (B) in the presence of the suitable aliphatic chain extender, whereby a randomly segmented multi-block copolymer is obtained

26. Process for preparing a copolymer according to any of the claims 1-24, comprising a coupling reaction, wherein pre-polymers A and B are both diol or diacid terminated and the chain-extender is di-carboxylic acid or diol terminated, respectively, using a coupling agent.

27. Process according to claim 26, wherein the coupling agent is dicyclohexyl carbodiimide (DCC).

28. Process for preparing a copolymer according to any of the claims 1-24, comprising a coupling reaction, wherein a BAB-pre-polymer is made by reacting a pre-polymer (A) with monomers which form pre-polymer (B), thus obtaining a BAB-tri-block pre-polymer, which is subsequently chain-extended using a multifunctional chain-extender.

29. Process for preparing a copolymer according to any of the claims 1-24, comprising a coupling reaction, wherein a ABA-pre-polymer is made by reacting a pre-polymer (B) with monomers that form pre-polymer (A), thus obtaining an ABA-tri-block pre-polymer, which is subsequently chain-extended using a multifunctional chain-extender.

30. Process according to any of the previous claims 25-29, wherein said chain-extender is selected from diisocyanate (preferably butanediisocyanate), di-carboxylic acid or diol, optionally in the presence of a coupling agent.

31. Process according to any of the previous claims 25-30, wherein said chain-extension reaction is performed in a solvent, preferably in 1,4-dioxane.

32. Use of a copolymer according to any of the claims 1-24 or a copolymer obtainable by a process according to claim 25-31 as a medical implant, including porous sponges, tubular devices, membranes, stents, a coating for a medical device, or a drug delivery vehicle.

33. Pharmaceutical composition for delivery of a bioactive agent comprising a copolymer according to any of the claims 1-24 loaded with said bioactive agent.

34. Composition according to claim 33 wherein the bioactive agent is chosen from the group of amino acids, (poly)peptides, proteins, nucleic acids, polysaccharides, steroids, growth factors, antigens, chemotherapeutic agents, hormones, antibiotics, antivirals, antifungals, immunosuppressants, antihistamines, anticoagulants, antiphoto-aging agents, melanotropic peptides, anti-inflammatory compounds, antipsychotics, radiation absorbers, decongestants, neuroactive agents, anesthetics, sedatives, vitamins, diagnostics (including radioactive isotopes and fluorescent agents).

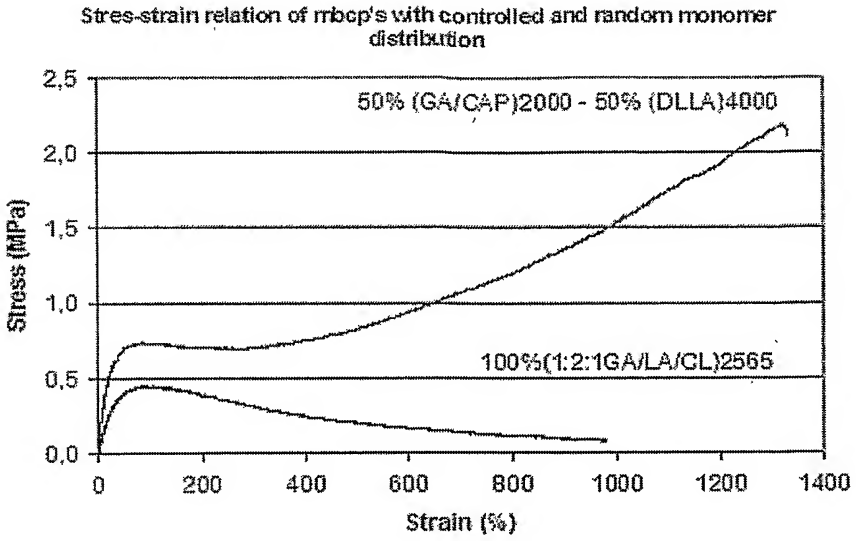

Figure 1a. Stress-strain curves of $100(GA_{50}LA_{25}CL_{25})_{2565}$ (entry 8, Table 2) with random monomer distribution and $50(GA_{50}CL_{50})_{2000}$-$50(LA)_{4000}$ (entry 2, Table 2) with controlled monomer distribution. For exact monomer composition, see Table 2

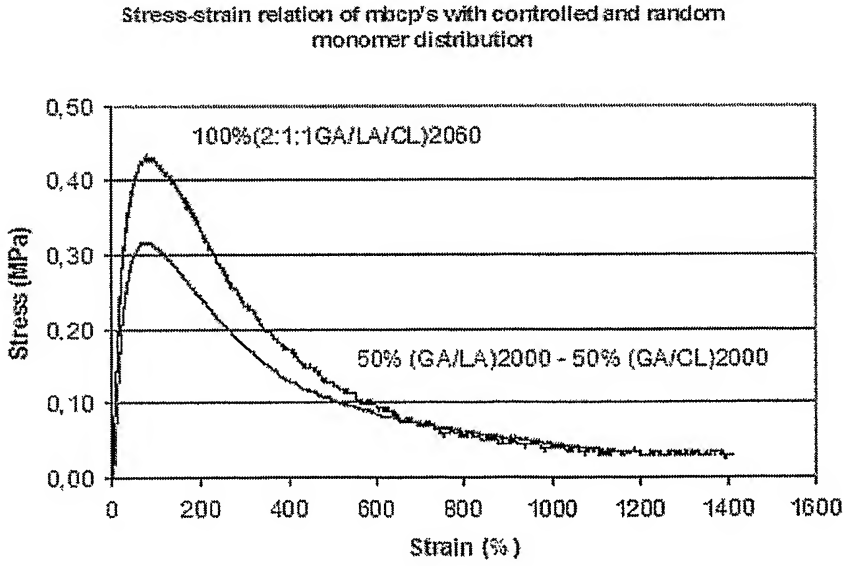

Figure 1b. Stress-strain curves of $100(GA_{50}LA_{25}CL_{25})_{2060}$ (entry 7, Table 2) with random monomer distribution and $50(GA_{50}LA_{50})_{2000}$ – $50(GA_{50}CL_{50})_{2000}$ (entry 5, Table 2) with controlled monomer distribution. For exact monomer composition, see Table 2.

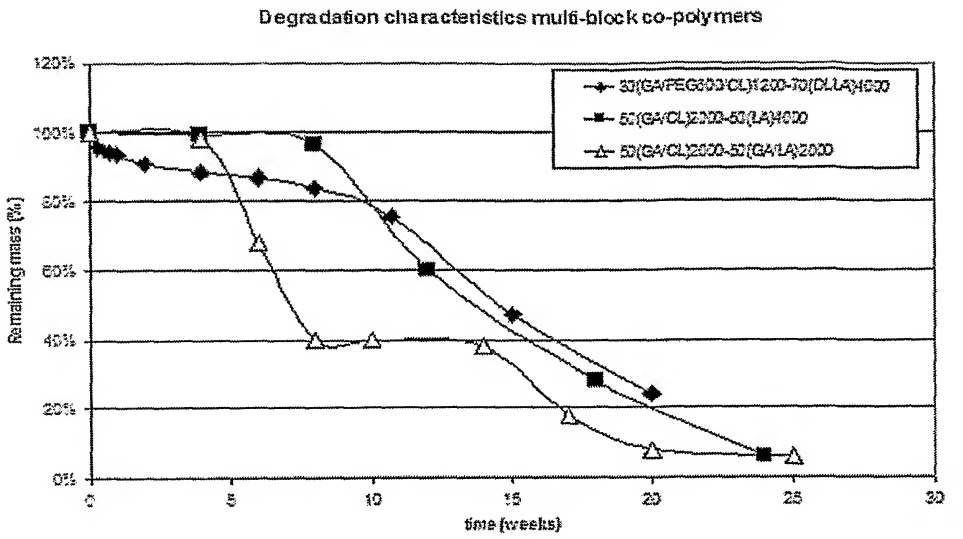

Figure 2: Mass loss characteristics of $30(GA_{50}CL_{50}$ PEG600$)_{1200}$-$70(LA)_{4000}$ (entry 9, Table 2), $50(GA_{50}CL_{50})_{2000}$-$50(LA)_{4000}$ (entry 2, Table 2) and $50(GA_{50}CL_{50})_{2000}$-$50(GA_{50}LA_{50})_{2000}$ (entry 5, Table 2) urethane-linked multi-block co-polymers.

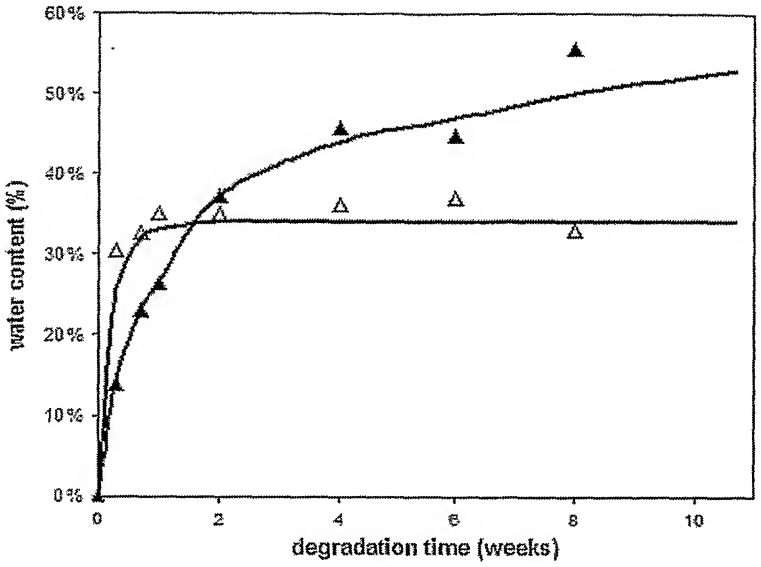

Figure 3a: Water uptake characteristics of $(GA_{50}CL_{50}\ PEG600)_{1200}$-$(LA)_{4000}$ urethane-linked multi-block co-polyesters with total PEG content of 15% (solid symbols; entry 9, Table 2) and 25% (open symbols; entry 10, Table 2).

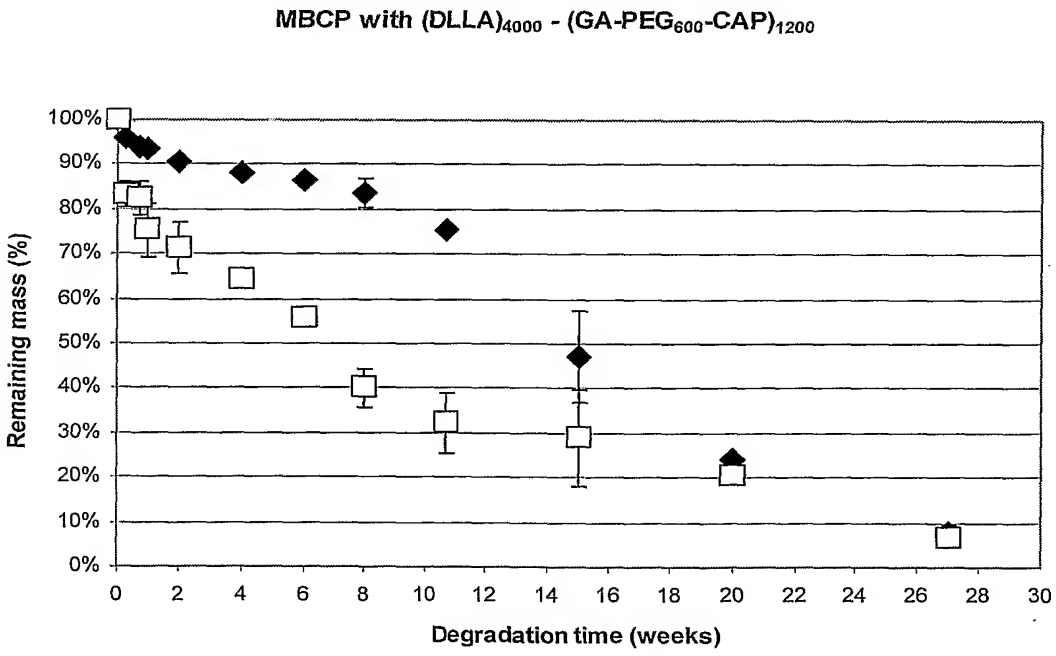

Figure 3b: Mass loss characteristics of $(GA_{50}CL_{50}\ PEG600)_{1200}$-$(LA)_{4000}$ urethane-linked multi-block co-polyesters with total PEG content of 15% (solid symbols; entry 9, Table 2)) and 25% (open symbols; entry 10, Table 2).

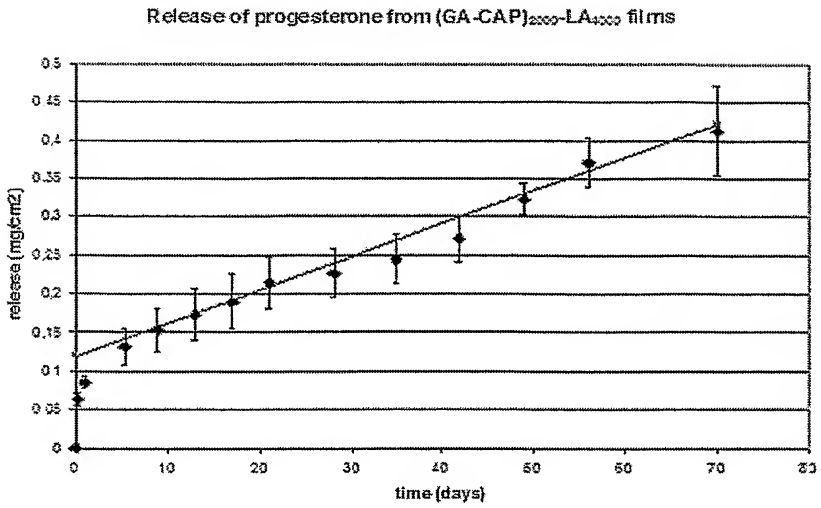

Figure 4 Cumulative release of progesterone from $50(GA_{50}CL_{50})_{2000}$-$50(LA_{4000})$ films

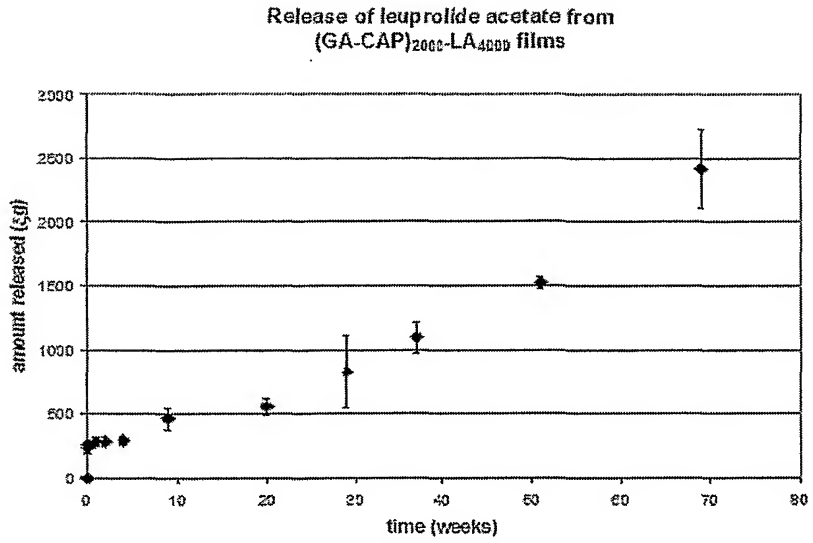

Figure 5. Cumulative release of leuprolide acetate from a urethane-linked $50(GA_{50}CL_{50})_{2000}$-$50(LA)_{4000}$ multi-block copolymer (drug load 20% w/w, film thickness 100 micron, sample weight 50-55 mg).

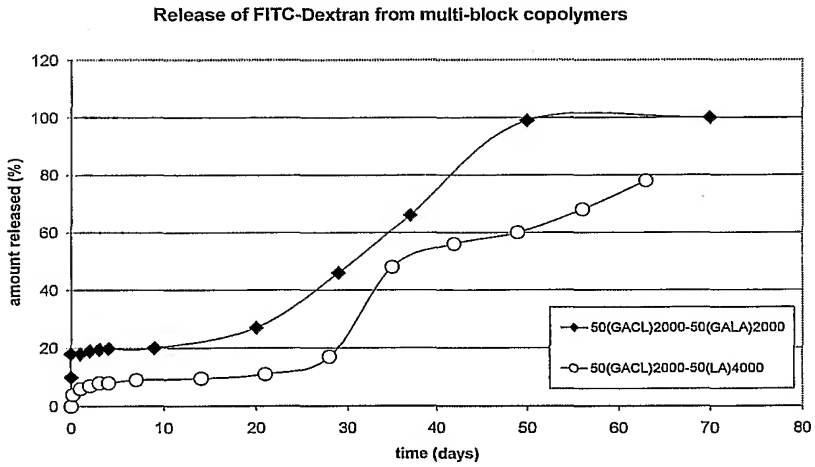

Figure 6 Effect of composition on cumulative release of FITC-dextran from urethane-linked $50(GA_{50}CL_{50})_{2000}$-$50(LA_{4000})$ and[$50(GA_{50}CL)_{2000}$-$50(LA_{50}GA_{50})_{2000}$] multi-block copolyester films (drug load 12 and 20% w/w respectively, film thickness ~80 mm, sample weight 50-55 mg).